REMARKS

Claims 1-26 are pending in the application. Claims 1-26 stand rejected. Claims 1, 16, and 21 were amended. Claims 1-26 remain in the application.

Claims 1, 12, 16, and 21-23 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Murayama (U.S. Patent No. 5,936,684) in view of Revankar (U.S. Patent No. 5,649,025). The rejection stated:

> "Regarding claims 1 and 12: Murayama discloses determining M reconstruction levels (M<N) based on the gray level distribution of the N level image (figure 4 and column 9, lines 34-39 of Murayama); and applying multilevel error diffusion (column 14, lines 56-62 of Murayama) to the N level digital image using the M reconstruction levels to produce the M level digital image (figures 8-9 and column 12, lines 58-62 of Murayama), wherein said determining further comprises assigning all of the pixels of said N level image into M groups corresponding to said M reconstruction levels (figure 4 and column 9, lines 7-18 of Murayama), and calculating each of said M reconstruction levels using the pixels of the respective said group (figure 4 and column 9, lines 34-39 of Murayama).
>
> "Murayama does not disclose expressly that said calculating necessarily follows said assigning.
>
> "Revankar discloses initially assigning pixels into M reconstruction levels (column 5, lines 6-9 of Revankar) before calculating each of said M reconstruction levels using the pixels of the respective said group (column 6, line 64 to column 7, line 5 of Revankar).
>
> "Murayama and Revankar are combinable because they are from the same field of endeavor, namely digital image data threshold determination. At the time of the invention, it would have been obvious to a person of ordinary skill in the art to iteratively perform the threshold determination, as taught by Revankar, thus initially assigning the value of the M cluster centers before the step of calculating. The motivation for doing so would have been that different portions, or segments, of an image can be better halftoned if multiple thresholds are applied to each region, rather than a single global thresholding (column 2, lines 25-31 of Revankar). Therefore, it would have been obvious to combine Revankar with Murayama to obtain the invention as specified in claims 1 and 12."

Claim 1 has been amended to state:

> 1. A method for multitone processing an N level digital image to produce an M level digital image wherein M and N have unchanging values and M<N, comprising the steps of:
>
> a) determining M reconstruction levels based on the gray level distribution of the N level image; and
>
> b) applying multilevel error diffusion to the N level digital image using the M reconstruction levels to produce the M level digital image;
>
> wherein said determining further comprises assigning all of the pixels of said N level image into M groups corresponding to said M reconstruction levels and, following said assigning, calculating each of said M reconstruction levels using the pixels of the respective said group.

This change makes even more explicit that the values of M and N are each fixed during the method. Claim 1 states: "M reconstruction levels ... M reconstruction levels ... wherein ... M groups ... M reconstruction levels". This emphasizes that the steps of Claim 1 are not recursive. This contrasts with the cited combination of references. The rejection stated, in this regard:

> "Revankar discloses initially assigning pixels into M reconstruction levels (column 5, lines 6-9 of Revankar) before calculating each of said M reconstruction levels using the pixels of the respective said group (column 6, line 64 to column 7, line 5 of Revankar)."

The cited portions of Revankar disagree with the rejection, since, in Revankar, thresholds are determined recursively, starting from a single threshold:

> "Step 2: Use a discriminant analysis-based method to find <u>a threshold T_l</u> for the histogram H, assuming that it is <u>bimodal</u>, and store the derived "goodness" value of the threshold T_l." (Revankar, col. 5, lines 6-9; <u>emphasis added</u>)

Revankar uses the term "T_l" to refer to the single initial threshold. Revankar continues:

> "Histogram E(i) is <u>recursively thresholded</u> at recursive threshold processor 308. The output of this processor are the filter threshold values and the goodness function.
>
> "The filter processor 310 operates to: 1) determine the number of significant thresholds through the cardinality of the threshold set and the filter threshold set (the number m), and 2) determine the m thresholds to be used based

on the largest goodness value out of the threshold set." (Revankar, col. 6, line 64 to column 7, line 5; emphasis added)

Claim 1 requires determining M reconstruction levels based on the gray level distribution of the N level image and applying multilevel error diffusion to the N level digital image using the M reconstruction levels to produce the M level digital image. This is unlike Revankar, which as the rejection indicates, provides recursive thresholding.

The cited step 2 of Revankar determines "a threshold T_I" (Revankar, col. 5, lines 6-9) Additional thresholds are added by repeats of step 3. (Revankar, col. 5, lines 10-15) In Revankar, the final number of reconstruction levels and number of recursions is not initially known, but the number of thresholds and number of reconstruction levels increases at each recursion. Revankar states:

> "In the proposed method, the histogram (original sample) is recursively cut into two pieces, and with each recursion smaller samples and less reliable thresholds are generated as the present goodness measure becomes less reliable. Therefore, for the sake of reliability, each histogram is cut as few times as possible. On the other hand it is necessary to cut the histogram at least as many times as the number of significant levels in the document, and that number is not known a priori. For a typical document, the constant k-4, i.e., we determined 7 thresholds that cut the histogram into 8 pieces. This maintains acceptable sample size for a 100 dpi or higher resolution page image. Furthermore, this agrees with the observation that documents usually have 2 or 3 levels and sometimes 4 levels, i.e. we need at most 3 thresholds of the 7 computed thresholds. In general, the constant value k should be greater than the number of levels in the document. Clearly, a user could guess at the number to enter the value through a user interface and assist the process in this determination." (Revankar, col. 5, line 51 to col. 6, line 3; emphasis added)

Even if the user guesses in Revankar, the process remains recursive and thus does not meet the language of Claim 1.

The combination of Murayama with Revankar would be recursive. In Murayama, a first threshold is calculated directly from a set of pixel values, and additional thresholds are calculated from the first threshold:

> "Next, in step s4 of FIG. 1, other threshold values are determined based on this first threshold value th[1]." (Murayama, col. 8, lines 23-24)

This approach tracks Revankar:

> "Step 3: Use threshold T_1 to divide the histogram into two sub histograms as in step 2 and find thresholds TJ1 and TJN for each sub histogram". (Revankar, col. 5, lines 10-12)
>
> "In the proposed method, the histogram (original sample) is recursively cut into two pieces, and with each recursion smaller samples and less reliable thresholds are generated". (Revankar, col. 5, lines 51-54)
>
> "Histogram J(i) is recursively thresholded at recursive threshold processor 304." (Revankar, col. 6, lines 56-57)

Murayama and Revankar are both unlike Claim 1 in this respect. Claim 1 requires that the determining step includes:

> "assigning all of the pixels of said N level image into M groups corresponding to said M reconstruction levels and, <u>following said assigning</u>, calculating each of said M reconstruction levels using the pixels of the respective said group".

In Claim 1, M reconstruction levels are calculated <u>following assigning</u> of pixels into M groups.

The rejection is also contradictory, in that it treats two different recursive thresholding procedures of Revankar as if they were a single procedure. The rejection says:

> "Revankar discloses initially assigning pixels into M reconstruction levels (column 5, lines 6-9 of Revankar) before calculating each of said M reconstruction levels using the pixels of the respective said group (column 6, line 64 to column 7, line 5 of Revankar)."

The rejection is here citing two different recursive thresholding procedures. The cite to column 5, lines 6-9 of Revankar relates to recursive thesholding of an <u>image intensity histogram</u>. (See Revankar, col. 4, line 59 to col. 5, line 9) The cite to column 6, line 64 to column 7, line 5 of Revankar relates to recursive thresholding of an <u>intensity transition histogram</u>. (See Revankar, col. 5, lines 25-36) This is apparent from Figure 6 of Revankar, which illustrates that there are two recursive threshold processors (items 304 and 308), each providing different recursive thresholding, resulting in two different sets of thresholds which are labeled "C_T" and "F_T" in Revankar. (See generally Revankar, col. 4, line 59 to col. 5 line 40) Neither of the sets of thresholds is used by itself. Revankar states:

"Step 5: Select the thresholds that have local maxima of goodness values." (Revankar, col. 5, lines 16-17; applied to intensity transition histogram in step 7--col. 5, lines 34-35; emphasis added)

"Step 8: Find the number of significant levels m by finding the cardinality of the smaller of the two sets C_T and F_T.

"Step 9: Select top m thresholds from C_T as the final thresholds based on their goodness values." (Revankar, col. 5, lines 37-40; emphasis added)

A combination of Murayama and Revankar would have to include Steps 8 and 9 of Revankar in order to provide multiple thresholds. (Revankar teaches using only some of the thresholds determined in the recursive thresholding of the image intensity histogram. See step 9, Revankar, col. 5, lines 39-40) In so doing, the combination would not meet the language of Claim 1, which requires determining M reconstruction levels based on the gray level distribution of the N level image; and applying multilevel error diffusion to the N level digital image using the M reconstruction levels to produce the M level digital image. Unlike Claim 1 the cited combination of references would require two recursive thresholding operations, following by picking the cardinality of the smaller of the two threshold sets.

Murayama also teaches against the combination of Murayama and Revankar. Murayama states:

'The aforementioned "Ohtsu method" provides technology suitable for setting the threshold values used in binary conversion, but when this is used without modification, for example to obtain four gradations, three times the processing volume is required as in binary conversion. In other words, in converting to four values, it is necessary to determine three threshold values. Consequently, it is necessary to first accomplish the process for determining the threshold value used in binary conversion and then to determine in a similar manner threshold values of each of the respective regions partitioned by this first threshold value. Consequently the process of binary conversion must be performed three times. Hence the volume of computations becomes enormous and a problem arises that a long processing time is required.' (Murayama, col. 1, lines 38-52)

'The invention can determine the n-1 threshold values needed to convert to n values (n>2) by adding slight computations to the so-called "Ohtsu method". The "Ohtsu method" is suitable for binary conversions. However, when this

method is applied without change for conversion to n values, where n is larger than two, the problem arises that the volume of computations becomes extremely excessive, as explained above. However, the invention reduces the amount of computations and moreover enables visually good gradation conversion.'
(Murayama, col. 2, lines 50-60)

Revankar is like the "Ohtsu method", in that the computation of additional thresholds, in the same manner as a first threshold, is required to provide additional levels. (Revankar, col. 5, lines 6-13) The combination of Revankar with Murayama is, thus, taught against.

Claim 12 is allowable on the same grounds as Claim 1.

As to Claim 16, the rejection stated:

"Regarding claim 16: Murayama discloses clustering all of the pixel values (figure 4 of Murayama) of the N level image into M (M<N) reconstruction levels (column 9, lines 34-39 of Murayama) based on the gray level distribution of the N level image (figures 2a-2b and column 9, lines 38-45 of Murayama); and minimizing error between the N level digital image and the M level digital image during said clustering (figure 2b; figure 5 (S23); column 8, lines 44-49; and column 10, lines 22-24 and equation 5 of Murayama). Two methods are used to minimize the error between the N level digital image and the M level digital image during said clustering. The first method is to evenly distribute the threshold values based on the cumulative histogram (figure 2b and column 8, lines 44-49 of Murayama). The second method is to maximize the interclass variance (figure 5(S23) and column 10, lines 22-24 and equation 5 of Murayama), which also distributes the threshold values as evenly as possible, thus minimizing the error between the N level digital image and the M level digital image during said clustering.

"Murayama further discloses applying multilevel error diffusion (column 14, lines 56-62 of Murayama) to the N level digital image using said M reconstruction levels to produce the M level digital image (figures 8-9 and column 12, lines 58-62 of Murayama).

"Murayama does not disclose expressly repeatedly revising said clustering of said pixel values into said reconstruction levels until error between thu N level digital images and the M level digital image is minimized.

"Revankar discloses repeatedly revising the clustering of pixel values into reconstruction levels (figure 6(304,306) and column 6, lines 56-65 of

Revankar) until a predetermined stopping condition is reached (column 6, line 64 to column 7, line 5 of Revankar).

"Murayama and Revankar are combinable because they are from the same field of endeavor, namely digital image data threshold determination. At the time of the invention, it would have been obvious to a person of ordinary skill in the art to iteratively perform the threshold determination, as taught by Revankar, and thus the clustering taught by Murayama until a predetermined stopping condition is reached, as taught by Revankar, which would be the minimum error taught by Murayama. The motivation for doing so would have been that different portions, or segments, of an image can be better halftoned if multiple thresholds are applied to each region, rather than a single global thresholding (column 2, lines 25-31 of Revankar), and it would have been clear to one of ordinary skill in the art at the time of the invention that minimizing error in image document reproduction is desirable. Therefore, it would have been obvious to combine Revankar with Murayama to obtain the invention as specified in claim 16."

Claim 16 states:

16. A method for multitone processing an N level digital image to produce an M level digital image wherein M and N have unchanging values and M<N, comprising the steps of:

clustering all of the pixel values of the N level image into M reconstruction levels based on the gray level distribution of the N level image;

repeatedly revising said clustering of said pixel values into said reconstruction levels until error between the N level digital image and the M level digital image is minimized; and

applying multilevel error diffusion to the N level digital image using said M reconstruction levels to produce the M level digital image.

As in Claim 1, the changed language makes even more explicit that the values of M and N are fixed during the method.

The rejection rearranges the steps of Murayama out of order. The rearrangement is unsupported in the rejection, unless the rejection improperly relies upon the claimed invention itself to provide this teaching. <u>The portions of Murayama cited in relation to "error minimization" relate to steps that precede the "clustering" step.</u> This precludes clustering followed by revising until error is minimized. The rejection

looks to step s5, discussed at Murayama, col. 9, lines 34-39 and Figure 4, in relation to clustering. The cited section is part of a larger discussion of step s5 of Murayama, Figure 1:

> "When the first through n-1st threshold values have been determined in this manner, an n value conversion process is then accomplished (step s5). Hereafter, this n value conversion process will be described with reference to FIG. 3. The flowchart in FIG. 3 shows an n value conversion process for one particular pixel." (Murayama, col. 8, lines 62-67)
>
> "Furthermore, the same process is accomplished for the next pixel. FIG. 4 shows the relationship between the respective brightness values (0 -255) of the pixels being processed, the first through third threshold values ..." (Murayama, col. 9, lines 33-36)

The rejection looks to steps s2, s3, and s4 in relation to minimizing error. As the nomenclature indicates, in Murayama, steps s2, s3, and s4 precede step s5:

> "FIG. 1 is a flowchart describing the processes of an embodiment of the invention. Hereafter, the order of these processes will be described." (Murayama, col. 7, lines 21-23)
>
> "First, the cumulative frequency distribution is determined for the image data input by the CCD camera (step s1)." (Murayama, col. 7, lines 24-25)
>
> "Next, the average $\mu 2$ and the standard deviation $\sigma 2$ of the brightness in the second class C2 are computed (step s2)." Murayama, col. 7, lines 47-48; emphasis added)
>
> "Furthermore, the first threshold value th[1] of the n-1 threshold values used in conversion to n values is determined (step s3)". Murayama, col. 7, lines 53-55; emphasis added)
>
> "Next, in step s4 of FIG. 1, other threshold values are determined based on this first threshold value th[1]." (Murayama, col. 8, lines 23-24; emphasis added)
>
> When the first through n-1st threshold values have been determined in this manner, an n value conversion process is then accomplished (step s5)." Murayama, col. 8, lines 62-64; emphasis added)
>
> (The rejection cites Murayama, Figure 5 (S23), col. 10, lines 22-24 and equation 5. All of these relate to S23, which is part of step s2 of Figure 1. (See legends on Figure 5: "FROM STEP S1 OF FIG.1" at the top and "GO TO S3 IN FIG. 1"

at the bottom.) The rejection also cites col. 8, lines 44-49. This is a discussion of step s4 of Figure 1. (See Murayama, col. 8, lines 23-49) The rejection cites Figure 2b, which shows setting of the threshold values. This relates to steps s3 and s4.)

In Murayama, step s5 follows steps s2-s4. This is not compatible with the language of Claim 16.

Claim 16 requires that the all of the pixel values of the N level image are clustered into M reconstruction levels based on the gray level distribution of the N level image and that this clustering is repeatedly revised until error between the N level digital image and the M level digital image is minimized. Murayama does not teach or suggest such repeated revision.

In the rejection, Murayama is combined with Revankar. The rejection argues that:

> "Revankar discloses repeatedly revising the clustering of pixel values into reconstruction levels (figure 6(304,306) and column 6, lines 56-65 of Revankar)".

It is not clear as to what part of Revankar the rejection is arguing constitutes repeatedly revising the clustering of pixel values. The rejection mentions reference numbers of the recursive threshold processor 304, which operates on the intensity histogram. (See Revankar, Figure 6 and col. 6, lines 56-59) The rejection also cites the intensity transition histogram generator 306. It is believed that the intended reference was to the second recursive threshold processor 308, which operates on the intensity transition histogram. (See Revankar, Figure 6, col. 6, lines 60-67) It is believed that the rejection is arguing that the recursive thresholding of the two different histograms constitutes repeatedly revising the clustering of pixel values. Revankar does not support this argument, since the recursive thresholding of recursive threshold processor 308 is not applied to pixel values but rather pixel intensity gradient values. (See Revankar, col. 5, lines 25-33; "where g'(x,y) is the pixel intensity gradient at location (x,y)" col. 5, line 33.)

The rejection fails to address that Claim 16 requires:

> "repeatedly revising said clustering of said pixel values into said reconstruction levels close quotation marks". (emphasis added)

The phrase "said reconstruction levels" refers to "M reconstruction levels". This language is not met by the recursive clustering of Revankar. Unlike Claim 16 and as

earlier discussed, Revankar does not teach clustering all of the pixel values of the N level image into M reconstruction levels based on the gray level distribution of the N level image followed by repeatedly revising the clustering of those pixel values into the M reconstruction levels. Revankar describes a recursive thresholding process that process adds additional thresholds (which would add additional reconstruction levels) at each recursion. Revankar states:

> "In the proposed method, the histogram (original sample) is recursively cut into two pieces, and with each recursion smaller samples and less reliable thresholds are generated". (Revankar, col. 5, lines 51-54)
>
> "Histogram H(i) is recursively thresholded at recursive threshold processor 304. The output of this processor are the threshold values and the goodness function." (Revankar, col. 6, lines 56-59)

Claim 16 requires repeatedly revising clustering of the pixel values into the reconstruction levels until error between the N level digital image and the M level digital image is minimized. The rejection states that Revankar teaches repeated revising:

> "until a predetermined stopping condition is reached (column 6, line 64 to column 7, line 5 of Revankar)."

The rejection fails to address the difference between the language of the rejection and Claim 16, which states in pertinent part:

> "repeatedly revising said clustering of said pixel values into said reconstruction levels until error between the N level digital image and the M level digital image is minimized".

This leaves the rejection of Claim 16 unsupported.

The cited portion of Revankar (column 6, line 64 to column 7, line 5) also does not teach a stopping condition. That portion of Revankar states:

> "Histogram E(i) is <u>recursively thresholded</u> at recursive threshold processor 308. The output of this processor are the filter threshold values and the goodness function.
>
> "The filter processor 310 operates to: 1) determine the number of significant thresholds through the cardinality of the threshold set and the filter threshold set (the number m), and 2) determine the m thresholds to be used based on the largest goodness value out of the threshold set." (Revankar, col. 6, line 64 to column 7, line 5; <u>emphasis added</u>)

This is a description of one of the two recursive thresholding operations in Revankar and of an operation that determines m thresholds from the two determined sets of thresholds. The stopping condition for the recursive thresholding of Revankar is described at col. 5, lines 14-15:

> "Step 4: Repeat step 3 for a constant k number of times. <u>The value of k is determined empirically</u>." (<u>emphasis added)</u>

Revankar indicates that in each repeat of step 3, a histogram H is divided into two sub histograms. (Revankar, col. 5, lines 10-13; see also lines 5-9) Step 4 is repeated for the recursive thresholding of the intensity transition histogram. (Revankar, col. 5, lines 34-36) Revankar also states:

> "In general, a constant value k should be greater than the number of levels in the document. Clearly, a user could guess the number to enter the value through a user interface and assist the process in this determination." (Revankar, col. 5, lines 66-67)

Revankar's stopping of recursive thresholding at constant value k is not revising of clustering of pixel values into <u>said</u> reconstruction levels until error is minimized:

> "In the proposed method, the histogram (original sample) is recursively cut into two pieces, and with each recursion smaller samples and less reliable thresholds are generated as the goodness measure becomes less reliable." (Revankar, col. 5, lines 51-55)

In Revankar, after recursive thresholding is completed, a determination is made as to which of the previously determined thresholds to user. The filter processor 310 determines the m thresholds to be used based on the largest goodness value out of the threshold set C_T rather than using the thresholds provided by k repeats of Step 3. (Revankar, col. 7, lines 1-5; col. 5, lines 39-40; the filter processor first performs step 8--see col. 5, lines 37-38 and col. 7, lines 1-3.) The combination of Murayama and Revankar would not teach more than Revankar in relation to this aspect of the rejection.

Claim 16 also requires:

> "clustering all of the pixel values of the N level image into M reconstruction levels based on the gray level distribution of the N level image;
>
> "repeatedly revising said clustering of said pixel values into said reconstruction levels until error between the N level digital image and the M level digital image is minimized"

and is allowable on the grounds discussed in relation to Claim 1 relating to M reconstruction levels.

The rejection stated in relation to Claim 21:

> "Regarding claim 21: Murayama discloses assigning pixels of the N level digital image to the M cluster centers to provide assigned pixels (column 8, lines 44-49 of Murayama); calculating values of said cluster centers based upon respective said assigned pixel (figure 4 and column 9, lines 34-45 of Murayama); selecting final values of said cluster centers as reconstruction levels (figure 4 and column 9, lines 34-39 of Murayama); and applying multilevel error diffusion (column 14, lines 56-62 of Murayama) to the N level digital image using said reconstruction levels to produce the M level digital image (figures 8-9 and column 12, lines 58-62 of Murayama).
>
> "Murayama does not disclose expressly setting initial values of M cluster centers; and repeating said assigning and said calculating until a predetermined stopping condition is reached and, thereby, final values of said cluster centers are defined.
>
> "Revankar discloses setting initial values of M cluster centers (column 5, lines 6-9 of Revankar); and repeating the overall threshold operations (figure 6(304,306) and column 6, lines 56-65 of Revankar) until a predetermined stopping condition is reached (column 7, lines 1-5 of Revankar) and, thereby, final values of said cluster centers are defined (column 7, lines 1-5 of Revankar).
>
> "Murayama and Revankar are combinable because they are from the same field of endeavor, namely digital image data threshold determination. At the time of the invention, it would have been obvious to a person of ordinary skill in the art to iteratively perform the threshold determination, as taught by Revankar, thus initially setting the value of the M cluster centers and repeating said assigning and calculating steps taught by Murayama until a predetermined stopping condition is reached, as taught by Revankar. The motivation for doing so would have been that different portions, or segments, of an image can be better halftoned if multiple thresholds are applied to each region, rather than a single global thresholding (column 2, lines 25-31 of Revankar). Therefore, it would have been obvious to combine Revankar with Murayama to obtain the invention as specified in claim 21."

Claim 21 states:

21. A method for multitone processing an N level digital image to produce an M level digital image wherein M and N have unchanging values and M<N, comprising the steps of:

setting initial values of M cluster centers;

assigning pixels of the N level digital image to said cluster centers to provide assigned pixels;

calculating new values of said cluster centers based upon respective said assigned pixels;

repeating said assigning and calculating until a predetermined stopping condition is reached and, thereby, final values of said cluster centers are defined;

selecting said final values of said cluster centers as reconstruction levels; and

applying multilevel error diffusion to the N level digital image using said reconstruction levels to produce the M level digital image.

As in Claim 1, the changed language makes even more explicit that the values of M and N are fixed during the method. This contrasts with Revankar, which requires recursive thresholding.

The rejection stated:

"Revankar discloses setting initial values of M cluster centers (column 5, lines 6-9 of Revankar); and repeating the overall threshold operations (figure 6(304,306) and column 6, lines 56-65 of Revankar) until a predetermined stopping condition is reached (column 7, lines 1-5 of Revankar) and, thereby, final values of said cluster centers are defined (column 7, lines 1-5 of Revankar).

Claim 21 is allowable over cited combination of references, since as discussed in relation to Claims 1 and 16, the combination of the cited references teaches recursive thresholding. This is unlike Claim 21, which requires:

"setting initial values of <u>M cluster centers</u>;

"assigning pixels of the N level digital image to <u>said cluster centers</u> to provide assigned pixels;

"calculating new values of <u>said cluster centers</u> based upon respective said assigned pixels;

"repeating said assigning and calculating until a predetermined stopping condition is reached and, thereby, final values of said cluster centers are defined;

"selecting said final values of said cluster centers as reconstruction levels". (emphasis added)

In Claim 21, each mention of "said cluster centers" refers back to any earlier mention of "said cluster centers" and to the "M cluster centers" of the setting step. This language means that these steps are not recursive. The cited combination of references teaches recursive thresholding.

Claim 21 also requires:

"repeating said assigning and calculating until a predetermined stopping condition is reached and, thereby, final values of said cluster centers are defined".

The rejection argues that Revankar discloses setting initial values of M cluster centers (column 5, lines 6-9 of Revankar). Revankar does not support this position. The cited portion of Revankar describes "step 2", in which a single threshold is set and the histogram is bimodal. Step 2 is followed by recursive thresholding. (See Revankar, col. 5, lines 6-15)

The rejection also argues that Revankar teaches repeating thresholding until a predetermined stopping condition is reached and, thereby, final values of said cluster centers are defined (column 7, lines 1-5 of Revankar). As earlier discussed in relation to the other rejections, Revankar does not support the rejection. In the cited section of Revankar, the filter processor 310 determines the m threshold to be used based on the largest goodness value out of the threshold set rather than relying upon the constant value k. (Revankar, col. 7, lines 1-5) In other words, unlike a stopping condition, the filter processor 310 acts to select m thresholds from the earlier determined threshold set C_T, which was determined using k repeats of step 3. (Revankar, col. 5, lines 39-40; the filter processor first performs step 8--see col. 5, lines 37-38 and col. 7, lines 1-3.) The combination of Murayama and Revankar would not teach more than Revankar.

The rejection proposes motivation for combining the cited references that is not supported by the references themselves. The rejection states:

"At the time of the invention, it would have been obvious to a person of ordinary skill in the art to iteratively perform the threshold determination, as taught by

Revankar, thus initially setting the value of the M cluster centers and repeating said assigning and calculating steps taught by Murayama until a predetermined stopping condition is reached, as taught by Revankar. The motivation for doing so would have been that different portions, or segments, of an image can be better halftoned if multiple thresholds are applied to each region, rather than a single global thresholding (column 2, lines 25-31 of Revankar)."

Murayama shows segmenting of an intensity histogram into two parts (see Figure 2(a)), followed by applying multiple thresholds to one of the regions (see Figure 2(b)). One of skill in the art would <u>not</u> be motivated to combine Murayama with another reference in order to provide a feature that was already present. <u>This leaves the proposed motivation for combining the references as applying multiple thresholds to each region, since Murayama already teaches applying multiple thresholds in one region.</u> One of skill in the art would also not be motivated to combine Murayama with Revankar, because applying multiple thresholds to each of the two initial regions in Murayama would render Murayama non-functional or degraded.

Murayama states:

> "Hence, it is an object of the invention to provide an image processing method and apparatus which can set threshold values for achieving a desired number of gradations, i.e., color shades or gray-scale, via <u>a simple process when an image processed with a high number of gradations is displayed on a display unit having a low number of gradations, and can set the desired number of gradations without shading being noticeable, even for images having shading</u>." (Murayama, col. 2, lines 16-23; emphasis added)
>
> "As explained above, in accordance with the invention, when image data with numerous values is converted into image data having a small number of gradations, it is possible to determine the first through n-1st (n>2) threshold values by merely adding a slight computation to the so-called Ohtsu method." (Murayama, col. 15, lines 1-6)
>
> "In addition, for images having shading that are photographed by an area sensor such as, for example, a CCD camera, a determination is made as to whether the pixels thereof are background or are meaningful information. In the case of background pixels, an n value conversion process is accomplished using a method that obtains two-dimensional gradations. When the pixel comprises meaningful information, such as characters, an n value conversion

process is accomplished using the above-described first through n-1st threshold values. Accordingly, a process is accomplished which preserves the edges in, for example, characters. Also, it is possible to accomplish an n value conversion process that reduces the effects of shading for information such as the background." (Murayama, col. 15, lines 14-27)

In contrast, the proposed combination of the rejection would add additional computations and additional thresholds applicable to the background pixels. (See Murayama, col. 2, lines 31-37)

Claims 22-23 are allowable as depending from Claim 21 and as follows.

The rejection stated in relation to Claim 22:

"Regarding claim 22: Murayama discloses that said assigning minimizes respective mean squared error (figure 5(S23) and column 10, lines 22-24 and equation 5 of Murayama). Maximizing the interclass variance (figure 5(S23) and column 10, lines 22-24 and equation 5 of Murayama), distributes the threshold values as evenly as possible. Since the equation for variance is based on the square of the difference between the respective classes (figure 5(23) and column 10, equation 5 of Murayama), the respective mean squared error is minimized."

The rejection of Claim 22 is self-contradictory. Claim 22 depends from Claim 21. The rejection of Claim 21 states:

"At the time of the invention, it would have been obvious to a person of ordinary skill in the art to iteratively perform the threshold determination, as taught by Revankar".

The rejection of Claim 22 ignores this and argues features of the threshold determination of Murayama. In effect, the rejection of Claim 22 argues against the rejection of Claim 21.

The rejection stated in relation to Claim 23:

"Regarding claim 23: Murayama discloses that the stopping condition is a predetermined threshold (column 8, lines 23-29 of Murayama). After the [n-1] th threshold has been determined, the threshold determination is stopped (column 8, lines 23-29 of Murayama)."

The rejection is arguing for a stopping condition that corresponds not to the procedure of column 7, lines 1-5 of Revankar, but rather to the constant value k of Revankar. As earlier discussed, in both recursive thresholding procedures of Revankar, step 3 is

repeated k times. (Revankar, col. 5, lines 14-15) The value of k is determined empirically and can be guessed at by the user. (Revankar, col. 5, line 15; col. 5, line 66 to col. 6, line 3) As earlier discussed, the procedure of Revankar does not stop when all of the thresholds have been determined. Revankar continues with:

> "Step 5: Select the thresholds that have local maxima of goodness values." (Revankar, col. 5, lines 16-17; applied to intensity transition histogram in step 7--col. 5, lines 34-35; emphasis added)
>
> "Step 8: Find the number of significant levels m by finding the cardinality of the smaller of the two sets C_T and F_T.
>
> "Step 9: Select top m thresholds from C_T as the final thresholds based on their goodness values." (Revankar, col. 5, lines 37-40; emphasis added)

The proposed stopping condition of Murayama is simply duplicative of the constant value k, unless one of skill in the art would substitute the threshold determination of Murayama for the threshold determination of Revankar. As discussed in relation to Claim 22, that approach is self-contradictory, since it argues against the rejection of Claim 21.

Claim 2 stands rejected under 35 U.S.C. 103(a) as being unpatentable over Murayama (U.S. Patent No. 5,936,684) in view of Merickel (U.S. Patent No. 4,945,478). The rejection stated:

> "Regarding claim 2: Murayama discloses determining M reconstruction levels (M<N) based on the gray level distribution of the N level image (figure 4 and column 9, lines 34-39 of Murayama); and applying multilevel dithering (column 14, lines 56-62 of Murayama) to the N level digital image using the M reconstruction levels to produce the M level digital image (figures 8-9 and column 12, lines 58-62 of Murayama).
>
> Murayama does not disclose expressly that said determining step comprises performing a K-means clustering operation on the N level digital image, wherein K=M.
>
> "Merickel discloses performing a K-means clustering operation on an N level digital image (column 11, lines 26-31 and column 15, lines 9-16 of Merickel).
>
> "Murayama and Merickel are combinable because they are from the same field of endeavor, namely the setting and manipulation of digital image levels to better show the image. At the time of the invention, it would have been

obvious to a person of ordinary skill in the art to perform a K-means clustering operation, as taught by Merickel, on the N level digital image taught by Murayama. Since the pertinent number of levels in Murayama is the M number of levels for the digital image, K would equal M when the teachings of Merickel are combined with the primary teachings of Murayama. The motivation for doing so would have been that applying a K-means clustering algorithm would optimize the cluster assignments for the pixels since, upon completion of the iterations, less than one percent of the pixels change cluster assignments (column 11, lines 50-55 of Merickel). Therefore, it would have been obvious to combine Merickel with Murayama to obtain the invention as specified in claim 2."

Combining the K-means clustering of Merickel into the method of Murayama would provide a combination unsatisfactory for the intended purpose of Murayama. In Murayama, a first threshold is calculated directly from a set of pixel values, and additional thresholds are calculated from the first threshold, until a desired number of levels is reached:

> "Next, in step s4 of FIG. 1, other threshold values are determined based on this first threshold value th[1]." (Murayama, col. 8, lines 23-24; also see the abstract)

This meets the object of Murayama of providing a simple process, since computations are reduced relative to use of the "Ohtsu method" for calculating each threshold. (Murayama, col. 2, lines 16-23 and 53-60) Murayama states:

> 'The aforementioned "Ohtsu method" provides technology suitable for setting the threshold values used in binary conversion, but when this is used without modification, for example to obtain four gradations, three times the processing volume is required as in binary conversion. In other words, in converting to four values, it is necessary to determine three threshold values. Consequently, it is necessary to first accomplish the process for determining the threshold value used in binary conversion and then to determine in a similar manner threshold values of each of the respective regions partitioned by this first threshold value. Consequently, the process of binary conversion must be performed three times. Hence the volume of computations becomes enormous and a problem arises that a long processing time is required.' (Murayama, col. 1, lines 37-51)

"Hence, it is an object of the invention to provide an image processing method and apparatus which can set threshold values for achieving a desired number of gradations, i.e., color shapes or gray-scale, via a simple process when an image processed with a high number of gradations is displayed on a display unit having a low number of gradations, and can set the desired number of gradations without shading being noticeable, even for images having shading." (Murayama, col. 2, lines 16-23)

"The "Ohtsu method" is suitable for binary conversions. However, when this method is applied without change for conversion to n values, where n is larger than two, the problem arises that the volume of computations becomes extremely excessive, as explained above. However, the invention reduces the amount of computations and moreover enables visually good gradation conversion." (Murayama, col. 2, lines 53-60)

In the proposed combination of the rejection, rather than calculating additional thresholds from a first threshold, as in Murayama; each of a plurality of clusters are calculated at the same time and then the calculations are repeated over and over, until a stopping criteria is reached. Merickel states:

"The K-means procedure computes the distance between each pixel and each of the K cluster centers, and associates that pixel with the cluster with the closest means, i.e., the smallest distance value. The distance measure used is the statistical distance (also known as the Mahalanobis distance) and is equivalent, in the one-dimensional case, to dividing the squared Euclidean distance from the pixel to the cluster center by the variance of the cluster; $D_j=(x-x_j)^2/\sigma_j$. Once all of the pixels have been assigned to a cluster, new cluster centers are computed to be the mean of all of the pixels in each cluster. Then the covariance matrix is computed for each cluster, and the inverse covariance matrix is also computed because it is needed to calculate the Mahalanobis distances. This K-means clustering algorithm repeats until either less than one percent of the pixels change cluster assignments in any one iteration, or until the maximum number of K-mean iterations, I_k, have been completed, where I_k is set equal to a large value such as 20." (Merickel, col. 11, lines 35-50)

As noted above, Murayama teaches against <u>three repeats</u> of the calculations of Ohtsu and instead provides a <u>simple</u> process. The modification of Murayama with Merickel to provide an indeterminate number of repeats subject to a stopping criteria would no

longer be a simple process. Such a modification of Murayama would increase complexity and, thus, render the resulting combination unsatisfactory for its intended purpose. A measure of the complexity that would be added by use of K-means clustering is presented in *Pattern Classification*, 2nd ed., R.O. Duda, P.E. Hart, D.G. Stork, John Wiley & Sons, Inc., New York, (2001), in the section entitled "10.4.3 *k*-Means Clustering", pages 526-527 provides a measure of the inherent complexity of K-means clustering. This reference presents the k-means clustering algorithm and then states:

> "The computational complexity of the algorithm is O(ndcT) where d is the number of features and T is the number of iterations". (page 527; n is the number of patterns and c is the same as "k" in the term k-means (see page 526-527). These pages of this reference were earlier submitted in an information disclosure statement.)

The rejection presents as motivation for combining Murayama and Merickel, the statement that:

> "The motivation for doing so would have been that applying a K-means clustering algorithm would optimize the cluster assignments for the pixels since, upon completion of iterations, less than one percent of the pixels change cluster assignments (column 11, lines 50-55 of Merickel).

This motivation fails, since the combination of Murayama and Merickel does not teach or suggest this result. The cited feature, "less than one percent of the pixels change cluster assignments", is only part of the stopping criteria for the iterations of K-means clustering of Merickel. The entire criteria is:

> "This K-means clustering algorithm repeats <u>until either</u> less than one percent of the pixels change cluster assignments in any one iteration, <u>or</u> until the maximum number of K-mean iterations, I_k, have been completed, where I_k is set equal to a large value such as 20." (Merickel, col. 11, lines 50-55; <u>emphasis added</u>)

If the proposed motivation were modified to follow the actual language of Merickel, the proposed motivation would change into: to optimize the cluster assignments for the pixels or to stop after a large number of iterations, such as 20. The rejection does not overcome the motivation in Murayama to not change Murayama so as to add repeated calculations. Murayama states, referring to the problems of repeating the Ohtsu method:

"Consequently, the process of binary conversion must be performed three times. Hence the volume of computations becomes enormous and a problem arises that a long processing time is required." (Murayama, col. 1, lines 49-52)

One of skill in the art would not be motivated to modify Murayama so as to re-create the problem originally solved by Murayama. The teaching of Murayama against three repeats of the calculations of Ohtsu provides motivation for one of skill in the art to not modify Murayama with the K-means clustering of Merickel.

The rejection states:

"Since the pertinent number of levels in Murayama is the M number of levels for the digital image, K would equal M when the teachings of Merickel are combined with the primary teachings of Murayama."

This position that K would equal M in the proposed combination of Murayama and Merickel is unsupported. It can be equally well argued, that the combination of references would apply the stepwise approach of Murayama. In that case, K-means clustering would be applied multiple times, with K equal to two each time. (See the above-quoted sections of Murayama) This approach of applying K-means clustering multiple times with K = 2 each time, is closer to the approach of Murayama and is unlike the claimed invention. The burden remains upon the Patent Office to present support for the position taken in the rejection.

Claims 3 and 13 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Murayama (US Patent 5,936,684) in view of Ishiguro (US Patent 6, 501, 56.6 B1). The rejection stated in relation to Claim 3:

"Regarding claim 3: Murayama discloses determining M reconstruction levels (M<N) based on the gray level distribution of the N level image (figure 4 and column 9, lines 34-39 of Murayama); applying multilevel error diffusion (column 14, lines 56-62 of Murayama); applying multilevel error diffusion (column 14, lines 56-62 of Murayama) to the N level digital image (figures 8-9 and column 12, lines 58-62 of Murayama); and forming a histogram of the N level digital image (figure 2a and column 7, lines 26-31 of Murayama).

"Murayama does not disclose expressly locating said M reconstruction levels corresponding to the M most prominent peaks in the histogram.

"Ishiguro discloses locating M reconstruction levels (denoted by N in Ishiguro) (column 3, lines 24-25 of Ishiguro) corresponding to the M most

prominent peaks in the histogram (figure 7 and column 7, lines 23-26 and lines 59-65 of Ishiguro). A histogram is created (figure 7 and column 7, lines 23-26 of Ishiguro) which set the pixel reference levels based on the number of pixels with densities within a set range (figure 7 and column 7, lines 59-65 of Ishiguro). As can clearly be seen from figure 7 of Ishiguro, this results in the four density levels (SO to S3) corresponding to the four most prominent peaks in the histogram. This is further evidenced by the language of claim 14 of Ishiguro (column 10, lines 57-60 of Ishiguro).

"Murayama and Ishiguro are combinable because they are from the same field of endeavor, namely digital image binarization. At the time of the invention, it would have been obvious to a person of ordinary skill in the art to set the M levels (M<N), taught by both Murayama and Ishiguro, based on the M most prominent peaks of said histogram, as taught by Ishiguro. The motivation for doing so would have been to prevent degradation of the image quality when error diffusion is performed, which is a common result for predetermined threshold values (column 2, lines 57-65 of Ishiguro). Therefore, it would have been obvious to combine Ishiguro with Murayama to obtain the invention as specified in claim 3.

The rejection has not presented a teaching or suggestion supporting the combination of the two cited references. The stated motivation is based upon a subjective criterion: "which is a common result".

The rejection proposed motivation for combining Murayama and Ishiguro:

> "The motivation for doing so would have been to prevent degradation of the image quality when error diffusion is performed, which is a common result for predetermined threshold values (column 2, lines 57-65 of Ishiguro)."

The cited portion of Ishiguro is a quotation from the Background of the Invention, which presents a problem in the prior art.

> "However, the conventional multi-value error diffusion process circuit had the disadvantage that the quality of the image data is degraded since the entire original document is subjected to the error diffusion process with a predetermined threshold value. For example, when there is a halftone image of uniform density in the original data such as halftone density text and that uniform

density differs from the predetermined threshold value, data resolution is reduced to degrade the picture quality of the image." (Ishiguro, col. 2, lines 57-65)

Ishiguro solves the indicated problem:

"An object of the present invention is to provide a image processing apparatus that can carry out an error diffusion process without degrading the quality of the image data." (Ishiguro, col. 3, lines 9-11)

The problem and solution stated in Ishiguro provide motivation for one of skill in the art to use Ishiguro to solve the problem of Ishiguro. This is not in and of itself motivation to use Ishiguro in combination with another reference.

The rejection does mention that the degradation of the problem solved by Ishiguro is "a common result for predetermined threshold values". This statement is subjective argument, which is not supported by the references. The cited language from Ishiguro describes a disadvantage of "the conventional multi-value error diffusion process circuit"; that term refers to a specific circuit, which is shown in Figures 10-14 described in great detail at col. 1, line 22 to col. 2, line 56. (See particularly, col. 1, lines 22-23 which states: "FIG. 10 is a block diagram showing a structure of <u>a conventional multi-value error diffusion process circuit</u>."; <u>emphasis added</u>) The rejection has made no showing that this circuit has any relationship to Murayama or that this circuit supports the terminology "a common result". In view of this, withdrawal of the rejection or presentation of documentary support for the proposed "common result" is demanded. (See MPEP 2144.03)

The rejection is also overcome by its failure to address the following factual showing, which is repeated here from the previous two amendments:

'Murayama and Ishiguro do not combine to teach the claimed invention. Murayama and Ishiguro teach two different types of histograms. Murayama teaches the setting of thresholds based upon a cumulative frequency distribution as shown by the <u>cumulative histogram</u> of Figures 2(a) and 2(b). (Murayama, col. 6, lines 42-44; col. 7, lines 25-27) Ishiguro discloses setting a threshold using a <u>non-cumulative</u> histogram of pixel densities. (Isihiguro, col. 7, lines 23-26) Murayama uses the cumulative frequency distribution of the cumulative histogram to meet the object of the invention of Murayama:

"Hence, it is an object of the invention to provide an image processing method and apparatus which can set threshold values for achieving a desired number of gradations, i.e., color shades or gray-scale,

via a simple process when an image processed with a high number of gradations is displayed on a display unit having a low number of gradations, and can set the desired number of gradations without shading being noticeable, even for images having shading.

"In order to achieve the above objects, the image processing method of the invention is of the type of image processing method wherein image data, having a brightness range in designated gradations and including at least a background and meaningful information existing in the background, is converted to image data in n gradations (n>2), with n differing from the designated gradations. The cumulative frequency distribution of the pixels is determined for each brightness range in the designated gradations. The average brightness and standard deviation of the part wherein the background is predominant are determined from this cumulative frequency distribution. A first threshold value that is an indicator of the boundary between the background and the meaningful information is determined on the basis of the average brightness and standard deviation." (Murayama, col. 2, lines 16-39; emphasis added)

In Ishiguro the threshold can be changed, as desired:

"Furthermore, the pixel of a particular density can be enhanced or the number of out gray levels can be adjusted by intentionally altering the condition for setting the threshold value (for example, by arbitrary setting by user)." (Ishiguro, col. 9, lines 31-35; emphasis added)

Assuming that one of skill in the art were motivated to combine Murayama and Ishiguro, the above-quoted portions to those references would provide motivation to use the process of Ishiguro with thresholds set by the cumulative frequency distribution and cumulative histogram of Murayama. This contradicts the rejection, which proposes the opposite.'

Applicants have shown motivation in the cited references for a combination, which would not teach or suggest the claimed invention. The Patent Office must consider the cited art as a whole. The burden is on the Patent Office to overcome this motivation.

Claim 13 is allowable as depending from Claim 3.

Claims 4-6, 18 and 24 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Murayama (US Patent 5,936,684) in view of Revankar (US Patent

5,649,025) and Ishiguro (US Patent 6, 501, 566 B1). Claims 4-6, 18, and 24 are allowable as depending from Claims 1, 16, and 21, respectively.

Claims 7 and 19 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Murayama (US Patent 5,936,684) in view of Revankar (US Patent 5,649,025), Merickel (US Patent 4, 945, 478), and Eschbach (US Patent 5, 565, 994). Claims 8, 10-11 and 20 rejected under 35 U.S.C. 103(a) as being unpatentable over Murayama (US Patent 5,936,684) in view of Revankar (US Patent 5,649,025), Merickel (US Patent 4,945,478), Eschbach (US Patent 5,565,994), and Klassen (US Patent 5, 621, 546). Claims 7-8 and 10-11 are allowable as depending from Claim 1 and Claims 19-20 are allowable as depending from Claim 16 and on the grounds discussed above, in relation to citations of Murayama in view of Revankar and Murayama in view of Merickel. As above discussed, Revankar applies recursive thresholding. Also as discussed above, it can be reasonably argued that a combination of Murayama and Merickel would teach a stepwise approach, in which K-means clustering would be applied multiple times, with K equal to two each time. (See the above discussion of Claim 2) This stepwise approach is recursive. A combination of Murayama with Revankar and Merickel would attempt to follow all of the references and, thus, would teach a recursive application of K-means clustering that is unlike the claimed invention. The burden remains upon the Patent Office to present support for the position taken in the rejection.

Claim 9 stands rejected under 35 U.S.C. 103(a) as being unpatentable over Murayama (US Patent 5,936,684) in view of Revankar (US Patent 5,649,025) and Klassen (US Patent 5,621,S46). Claim 9 is allowable as depending from Claim 1 and on the grounds discussed above in relation to citations of Murayama in view of Revankar.

Claim 14 stands rejected under 35 U.S.C. 103(a) as being unpatentable over Murayama (US Patent 5,936,684) in view of Ishiguro (US Patent 6,501,566 B1) and Eschbach (US Patent 5, 565, 994). Claim 15 stands rejected under 35 U.S.C. 103(a) as being unpatentable over Murayama (US Patent 5,936,684) in view of Ishiguro (US Patent 6,501,566 B1), Eschbach (US Patent 5,56-5,994), and Klassen (US Patent 5, 621, 546). Claims 14-15 are allowable as depending from Claim 3 and on the grounds discussed above, in relation to citations of Murayama in view of Ishiguro.

Claim 17 stands rejected under 35 U.S.C. 103(a) as being unpatentable over Murayama (US Patent 5,936,684) in view of Revankar (US Patent 5,649,025) and

Merickel (US Patent 4, 945, 478). Claim 17 is allowable as depending from Claim 16 and on the grounds discussed above, in relation to Claims 7-8, 10-11, and 19-20.

Claim 25 stands rejected under 35 U.S.C. 103(a) as being unpatentable over Murayama (US Patent 5,936,684) in view of Revankar (US Patent 5,649,025) and Eschbach (US Patent 5, 565, 994). Claim 26 stands rejected under 35 U.S.C. 103(a) as being unpatentable over Murayama (US Patent 5,936,684) in view of Revankar (US Patent 5,649,025), Eschbach (US Patent 5,565,994), and Klassen (US Patent 5,621,546). Claims 25-26 are allowable as depending from Claim 21 and on the grounds discussed above, in relation to citations of Murayama in view of Revankar.

It is believed that these changes now make the claims clear and definite and, if there are any problems with these changes, Applicants' attorney would appreciate a telephone call.

In view of the foregoing, it is believed none of the references, taken singly or in combination, disclose the claimed invention. Accordingly, this application is believed to be in condition for allowance, the notice of which is respectfully requested.

Respectfully submitted,

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